The uſes of a QUADRANT

P. II. 42. FITTED

For daily practiſe

Both with the ordinary lines for the *Houre* and *Azimuth*, and other things of the Suns courſe in reference to the *Horizon*.

And alſo with new Lines ſerving to the fore-mentioned and other purpoſes, more accurately.

As namely,

To find the houre of the Night by the Stars;
To deſcribe the moſt uſuall ſorts of Dials;
To perform all common things in Menſuration;
And many other requiſite concluſions.

In an accurate, eaſie, and delightfull way.

Publiſhed by ANTHONY THOMPSON.

LONDON.

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Thompson

AN Advertiſement to the READER.

Concerning the ſtructure and uſe of this Quadrant, the Reader may underſtand thus much. The Houre and Azimuth lines are like thoſe that are commonly ſeene upon other Quadrants, and the uſes are (moſt part) the ſame, and therefore are lightly paſſed over; as is ſeen in the ſecond Propoſition. But the Diſtance of the Equinoctial & Tropiques is here ſhortned, that ſo more room might be gained above, for the better placing, and the more accurate dividing of

the Equinoctials; which in ſmall inſtruments may receive each ſecond degree, in larger each ſingle degree, or more.

If it be required to make theſe yet larger, then may the fore-mentioned Azimuth lines be left quite out. For the uſe of them, as they are here deſcribed, is of ſmall moment, very hardly, making good the Suns coaſt to one entire degree: and for ſerious practiſe, the new Lines added are farre more ſufficient If this be granted, then may the Equinoctialls ſtand below, by which means they ſhall become large enough, even in ſmall Inſtruments. Eſpecially this may moſt fairly be done, if the hour-lines be reverted by changing the places of the Equinoctiall and Tropiques; that is, if the Equinoctiall altitudes be inſerted below on the circle neereſt the limb, and the Tropicall altitudes above in the circle neereſt to the center. Thus becomming more large, they will ſupply all intended purpoſes very well. There is no Scheme given of this change now mentioned, nor of the vulgar Houres and Azimuths, becauſe thoſe lines are well

enough

enough known already, and this mutation is easie to be understood. If other Quadrants were thought compleat in use, this will be found much more copious. For it serveth not onely to finde the hour of the day by the Sun: of the night by the Starres, and what else belongs to their Risings, Settings, Amplitudes, &c. but is very well fitted also to describe all the most usuall sorts of standing Dyals; that is, all that are upright, or else reclining or inclining to the full East and West: which two sorts will furnish many kinds of such bodies, as are regularly formed. These are here performed by very easie and familiar ways of working. The Nocturnall for the hour by the Stars, is more expedient in this then in other Quadrants. For in judging of time onely by the Appulse of the Stars to the Meridian, and finding that Meridian too onely by a rude conjecture from the North-starre, an errour of a quarter or half an hour is easily unawares committed. This cannot be so here if any ordinary care be had in taking the Stars altitude. For

this

this purpose, there are twelve select Stars inserted, all of them of North Declination, lying between the Equinoctiall and Tropique of Cancer; *and in such difference of right ascensions, as that one or other of them will be alwayes in such convenient place of the Heavens, as from whence the hour may very fully be collected every night throughout the whole year. Since therefore they are so convenient for use, there would be a little the more diligence used to come to the knowledg of them in the Heavens, that due observations may be made whensoever any of them shall be in view. If any desire that other starres (such as are better known to them) should be inserted, they may have their desire easily fulfilled. Onely they must take care, that the starres be such as fall between the Tropiques in the Heavens, and chiefly between the Equinoctiall and North Tropique; because such starres are longest in view, and their hours best found.---The Propositions that are here set down might have been increased both in number and in*

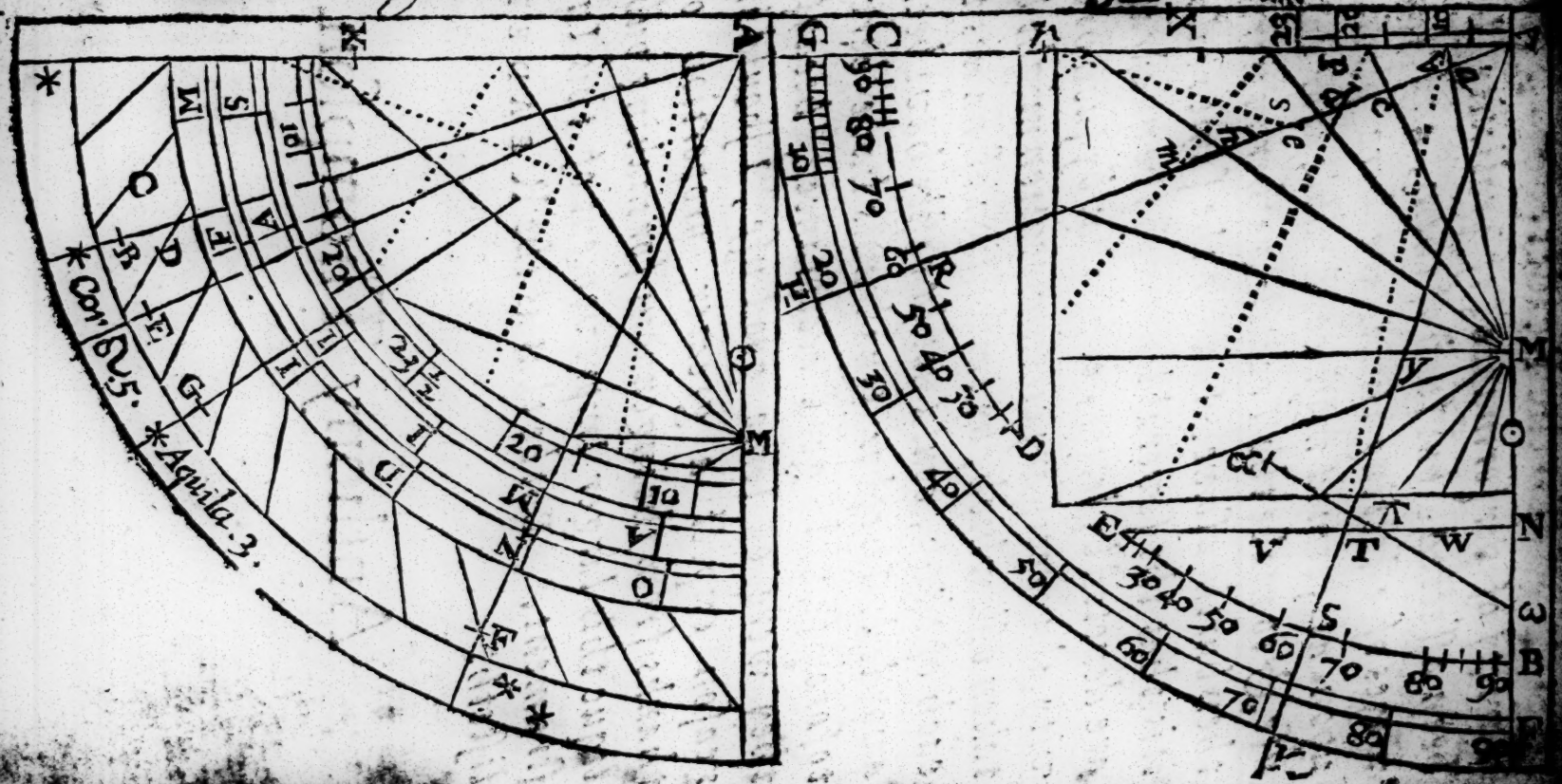
variety

variety of performance, if prolixity had been affected; but such of them, and such wayes of effecting them, are here pitched upon as seemed most conducible for daily use, & to make the Treatise, rather material then burthensome. And for the same reason it is, that the several lines upō the quadrant are denoted by letters only; that by such brevity, al unnecessary circumlocution might be taken off, which, by imposition of names to each of them, could not so easily have been avoyded. If other Quadrants have heretofore found good acceptance, because they were of some good use, I should in reason expect a greater proportion of thanks from the ingenuous for making publique this larger Improvement of this Instrument. But be that as the READER *listeth.*

Anthony Thompson.

1 AO 60 mg Radius MN de 32, 1/2 Hor. Complitudo

2 AM 60 mg Radius AO de Sine 54, 32



The uſes of the QVADRANT.

I. *To finde the Suns Declination.*

LAy the threed to the day of the moneth upon the back ſide of the Quadrant, and it will ſhew you the Declination of the Sun in that unequall ſcale, which is numbred with twice $23\frac{1}{2}$. If your day fall in the upper ſcale of moneths (which may be called the Summer ſcale) then is the declination North: if it fall in the lower (or Winter) ſcale, the declination is South from the Equinoctiall.

Thus upon *Aprill* 20, you ſhall find the ſun decline 15 *gr.* northward: and *January* 30, declines about $14\frac{1}{2}$ *gr.* ſouthward.

The contrary work is eaſie: by aſſigning the ſuns declination, to know on what day the moneth the ſame ſhall be. For the

threed may be laid to the declination in two places; in both which it will crosse the two halfe years, shewing two severall dayes on which the sun shall have so much declination North; and two more dayes on which it shall have that declination Southward. It will be easie to distinguish which of these days serves your purpose, by the two seasons of the year unto which the two scales of moneths doe answer.

II. *To rectifie the Bead for observation of Houre or Azimuth: and to perform those things that are done by the usuall lines upon the Quadrant.*

HAving found the Suns declination for your day, you must count the same upon the double equall scale which is on the foreside of the Quadrant, namely, from the middle of it towards the right hand, if the declination be North, or towards the left hand if it be South. The threed being laid thereto, you must move the bead, til it fal justly upon the houre of 12, so shall it be set right for the intended uses of that day. As,

1 *For the* HOURE. If you observe the sun al

altitude (by letting the Sun-beames to ſhine through the ſights, and the Plummet to hang at full liberty, cloſe to the plane of your quadrant) the bead will ſhew the houre, if you have reſpect to the time of the yeer. That is; If the ſuns declination be North, the bead ſhewes the time of the day among the Summer houres, thoſe which ſpread from the Equinoctiall towards the right hand. If the Sun decline South, the time muſt be accounted in the croſſe lines which are the winter hours. And in this obſervation you ſhall ſee the threed to cut (in the equall limbe) the Suns altitude above the Horizon.—— Thus at *London*, if the ☉ decline 15 *gr*. Northward, and the altitude were $9\frac{5}{12}$ *gr*. the hour would be about a quarter before 6 in the morning: Or a quarter paſt 6 in the evening. But if the Sun had the ſame declination Southward, and the ſame altitude alſo, then would the time be half an hour paſt 8, in the morning; Or halfe an hour paſt 3, in the evening. The former of theſe times is ſhewed by the bead among the ſummer-houres; the latter among the winter-hours.

2 *For the* AZIMUTH. If the ſuns altitude be numbred the contrary way in the equall limbe, and the threed be laid thereto, the bead

will then ſhew the *Azimuth* of the Sun if you account it according to the time of the yeer: That is, among the Summer *Azimuths* when the ſun hath North declination; and among the Winter Azimuths when the ſun declines South. The Summer Azimuths, are thoſe that ſpread from the Equinoctiall towards the left hand: The other croſſing them, are the Winter Azimuths. ——— Thus if the ſuns declination were 8 *gr.* Northward, and the altitude 18 *gr.* the Azimuth would be 80 *gr.* from the South. But if the ſun had 8 *gr.* of South declination, and 18 *gr.* altitude, the Azimuth would be 50 *gr.* from the South, here at *London*. This way may ſerve for groſſe workes, when the Azimuth is required onely within one or two whole degrees. You ſhall finde it done more accurately and for better purpoſes in the thirteenth following.

3 *For the* ASCENSIONALL *difference.* The bead being (rectified as before) and applied to the left ſide of the quadrant, gives the Aſcenſionall difference, or the time of ſun-riſing & ſeting before or after 6 a clock, among thoſe hours and quarters which interſect each other upon the ſame left ſide of the quadrant, if you account them agreeable to the time of the

the yeer. And from the bead to the line of 12 rightly taken according to your time of Summer or Winter, gives the ſemidiurnall Ark of the ſun, or half the dayes length. —As alſo, from the bead to the other line of 12, which ſerves for the contrary time of the yeer, gives the ſeminocturall Ark, or half the length of the night. ——— Thus if the ſuns declination were $14\frac{1}{3}$ *gr.* the Aſcenſionall difference would be 1 hour and $\frac{1}{4}$ of an houre. And if the ſaid declination were North, then the ſun riſeth that day $\frac{1}{4}$ of an hour before 5; ſetteth $\frac{1}{4}$ after 7: The ſemidiurnall arke (from the bead to the Summer 12) is $7\frac{1}{4}$ hours. The ſeminocturall arke (from the bead to the Winter 12 is $4\frac{3}{4}$ houres. Theſe doubled, make the day $14\frac{1}{2}$ hours long, The night $9\frac{1}{2}$ long.

4 *For the* AMPLITUDE. The bead applyed to the right ſide of the quadrant gives the *Amplitude* of ſun riſing and ſetting, in all varieties. Namely; From the bead to that South Azimuth which is proper to the ſeaſon of the yeer, is the *Amplitude* from ſouth: as alſo to the contrary ſouth Azimuth, gives the *Amplitude* from North: ſhewing how many degrees of the Horizon the ſun riſeth and ſetteth any day from the juſt South or North. So from the bead to the Eaſt and Weſt Azi-

muth (which is the ninth Azimuth) gives the Amplitude from East or West. ——Thus if the ☉ decline 14 ⅓ *gr.* The Amplitude is here, 23 ⅓ *gr.* almost. If the declination be North, then is this Amplitude from East and West toward the North, 23 ½ degrees. The Amplitude from the north it self is then 66 ½ *gr.* From the south point of the Horizon it is 113 ½ *gr.* You may easily (in such manner) account it for South declinations of the ☉.

V. *To finde when Twilight begins in the Morning and ends at Evening: which moments are the two utmost termes of darke night.*

AFter the bead is rectified for your day, The threed laid to 18 *gr.* in the equall limbe, will shew the houre or part required. Onely here remember to take your hour aright. Namely, in winter time, look among the Summer houres, where it is that the bead resteth, for that is the Morning or Evening hour of Twilight. So in summer time you must look among the winter hours.——Thus when the ☉ declines 11 ⅒ *gr.* Southward, the twilight begins at *London* at 5 in the morning, and ends at 7 a clocke at night, as the bead shewes

ſhewes among the ſummer houres. But if that declination were North, the twilight would begin at $\frac{1}{4}$ of an hour before 3 in the morning, and ende $\frac{1}{4}$ after 9 at night. --The ſuns depreſſion 18 *gr.* under the Horizon, is the uſuall terme whereon to begin and end the twilight. You may as well do this to any degree of light, as to 12, or 13 degrees depreſſion: At which time in the morning all things begin to be viſible, and the light to be of ſome uſe. As if the ☉ decline $3\frac{1}{2}$ *gr.* Southward, if you ſet the bead thereto, and then lay the threed at 12 *gr.* in the equall limbe, you ſhall ſee the bead (among the ſummer houres,) fall upon 5, in the morning and 7, at night, So that at 5, and till 7, there is a reaſonable degree of light. Or if in ſummer the ☉ had declined $7\frac{1}{2}$ *gr.* Northward; the ſaid degree of light would begin at 4, in the morning, and end at 8 in the evening.----Neer to the longeſt days you ſhall finde no twilight at all according to 18 degrees depreſſion of ☉ under the Horizon: for then the bead will fall beyond the Winter 12 a clock-line.

¶ Theſe are the chief uſes of the hour and Azimuth lines as they are here, and in all Quadrants commonly inſerted. There are other things concerning the ſuns place in the

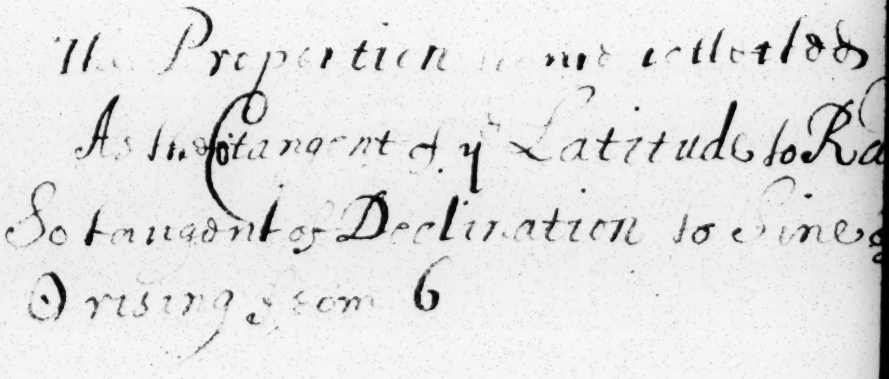
the Ecliptick: The ſuns declination: The ſuns right aſcenſion: Namely, ---How by having any one of theſe, to finde out the reſt --Theſe are here omitted as matters onely of curioſity, being of no further uſe, in this inſtrument, then that they may be known. Yet if any ſhould deſire them, they may have a Scale of the 12, ſignes inſcribed on the back ſide; by help of which, the fore-named requiſites may be attained. The particulars that follow are moſt aimed at, (as being more of them, and more accurate) and therefore the precedent things are thus briefly paſſed over.

III. *To finde the Suns Aſcenſionall difference, &c.*

COunt the declination in the equall limbe from F, to K. The threed there laid, gives BS the Aſcenſionall diffeence.--The ſaid aſcenſional difference gives the times of ſun riſing and ſetting before and after 6: with the lengths of Day and Night.---The ſame may be done for all ſtars whoſe declinations are known.

¶ So by having the aſcenſionall difference

you


The Proportion is called
As Sin: tangent of Latitude to Ra
So tangent of Declination to Sine
Arising from 6

you may finde the ſuns declination thereto belonging.

Here at *London*, if the declination be 20 *gr.* the aſcenſionall difference is 27 *gr.* 14 min. That is, 1 houre, 49 minutes. And if this declination be North, the ſun riſeth 1 hour 49 min. before 6, and ſetteth ſo much after 6. That is, it riſeth 11 min. after 4 in the morning; and ſetteth 49 min. after 7 a clock at night. And the time of ſetting being doubled, gives 15 hours, 38 min. for the dayes length. The time of riſing being doubled, gives 8 hours, 22 min. for the length of night. But if the declination had been South, the ſun ſhould riſe 1 hour, 49 min. after 6 (that is, at 7, 49 min.) And ſhould ſet 1 hour, 49 min. before 6 (that is, at 4 and 11 min.) and the day would be 8 hours, 22 min. long; the night 15 hours, 38 min.

IV. *To finde the ſuns Amplitude, &c.*

COunt the declination in the equall limbe from G to H. The threed there laid, gives C R for the Amplitude. -----The ſame may be done for ſtars whoſe declinations are known.

℄ So by having the Amplitude, you may finde the declination. For if the Amplitude be counted from C to R, the threed laid at R, gives the declination G H.

At *London*, if the declination be 20 *gr.* the Amplitude is 32 *gr.* 20 min. from the East and West points of the Horizon.

V. *Having the declination of any upright plane, to finde the elevation of the ſtyle, &c.*

LAy the threed to the planes declination, counted from D to R: So will G H be the Elevation.

℄ So by having the Elevation G H, you may finde D R the declination.

If an upright plane (here) decline 20 *gr.* the ſtyles elevation will be 35 *gr.* 48 minutes

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VI. *To finde the Deflexion, &c.*

COunt the declination from B to S. The threed there laid, gives F K the Deflexion.

℄ So by having F K the Deflexion, you may finde B S, the planes declination.

If

If A plane declining 20 *gr.* the Deflexion is 15 *gr.* 13 min.

VII. *To finde the planes Difference of longitude, &c.*

1 COunt the Elevation from F to K. E S is the difference of longitude.

2 Count the Deflexion from G to H. C R is the difference of longitude.

℄ By the contrary works, having the difference of longitude, you may finde the Elevation and Deflexion.

A plane declining 20 *gr.* hath 25 *gr.* diff. of longitude.

VIII. *To make an Horizontall Diall.*

1. COunt the houre from E to S: The threed laid at S, gives F K. Then count G H equall to F K: The threed there laid gives D R, the ſpace of that hour from 12.

2. Count the hour from C to R, and by help of the threed you ſhall have G H. Then count F K equall to G H: the threed laid at R, gives B S, for the ſpace of that hour from 12.

3. With

3 With a paire of compaſſes, take the hour from C to R, and ſet it from B to S. B S is the ſpace or angle of that houre from twelve.

4 Take with your compaſſes the hour from E to S, and ſet it from D to R. So the number D R ſhews how many degrees that houre muſt be from 12.

By all theſe waies (here at *London*) the third hour will be found about 38 *gr.* from 12. The reſt will be in like manner found according to their true quantities.

IX. *To finde what Angle any hour-circle maketh with the Horizon ; or any Azimuth makes with the Equinoctiall.*

LEt the number of the hour-circle (or *Azimuth*) from ſouth, be counted from C to R the threed laid at R, will cut the equall limbe in H. And F H will be the angle required.

℄ By the angle know, it will be eaſie by the

As Radius to ~~the~~ complement of the
Latitude So Cosine of the hours
from y^d^ meridian or Sine of it
beyond 6 to complement of the arke of
ye hours betwixt the Equinoctiall and
the north declination wherein
12 and 6 add the declination to
the hours arke beyond 6 Subtract
the former arke out of ye Declinatio^n^
and you have the arke of the course
Orbe intercepted in equinoctiall
or 6 ye Declination & ye parallell

the contrary worke, to finde the houre (or Azimuth) to which that angle belongeth.

The third houre (or 45 Azimuth) makes with the Horizon (or with the Equinoctiall) an angle of *63 gr. 53 minutes* here at *London.*

X. *To finde what arke of any houre-circle is intercepted betweene the Equinoctiall (or any Parallel) and the Horizon.*

COunt the number of the houre-circle from South, from E to S: or if it be above 90, from E to B, and back again to S. So F K in the equall limbe, will be the arke required, betweene the Equinoctiall and Horizon.

The arke intercepted between any parallel and the Horizon, may hence alſo be found. ——If the Declination of the parallel be North, and the houre be between 12 and 6, Add the declination to the arke found by the former worke: In other houres beyond 6, ſubtract the former ark out of the declination, the reſult will be the ark required. Upon the hour

of

of 6 it self, the declination of the parallel
the ark intercepted.——If the declinatio
be South, Subtract it out of the arke foun
before, (namely, the ark intercepted betwee
the Equinoctiall and Horizon) what remain
is the ark intercepted between that paralle
and the Horizon.

Thus at *London*. The ark of the 3 hour inter-
cepted between the Equinoctiall and Hori-
zon, is 29 *gr.* 21 min.——And if the decli-
nation be 18 *gr.* North, the arke intercepte
between that parallel and the horizon, is 47 *gr.*
21 min.——If the parallel be 18 *gr.* South
the arke will be 11 *gr.* 21 min.

¶ The first worke, will also shew what ark
of any *Azimuth* from South is intercepted be-
tweene the Horizon and Equinoctiall, if in
stead of the hour-circle from South, you us
the *Azimuth* from South. This intercepte
arke, is the Equinoctiall altitude of that *A-
zimuth*.

So in the 45 *Azimuth* from South, the
Equinoctiall is 29 *gr.* 21 min. high. In the 135
Azimuth from South, the Equinoctialls de-
pression under the horizon, in 29 *gr.* 21 min.

This is made use of afterwards.

XI. *Ho*

In South declination Subduct
it out of the ~~South~~ arke found
before

Thus the arke of the Azimuth
intercepted betweene ye Horizon
and Equinoctiall is also found

Nota

As Radius to Cotangent of the
Latitude So Sine of the excess
of an Azimuth above 90 degrees
To tangent of that Azimuths
depression under the Horizon viz
the quantity of the ☉ depression

XI. *How high the Sun ſhall be upon any Azimuth, and in any Declination.*

THe *Azimuth* is beſt numbred from the ſouth. And this propoſition (with moſt of thoſe that follow) is to be done by helpe of compaſſes.

℄ If the ☉ be in the Equinoctiall, the firſt worke of the laſt propoſition gets the Equinoctiall altitude or depreſſion, by counting the *Azimuth* from E to S, whereby the arke FK will be found. This arke (if the *Azimuth* be leſſe than 90) is the altitude: if more than 90, it is the depreſſion.

But if the ſun have Declination, then. Firſt, lay the threed from F towards K according to that Declination, and take the leaſt diſtance from the point B, to your threed, and keep this extent. Then,

℄ If the ſuns declination be ſouth; Count your *Azimuth* from E to S, and lay the threed there, which will cut the line E N, in T. Set one foot of the former Extent in T, and turn the other about toward the ſide A B, applying the threed to the remoteſt diſtance of that circuit. The threed ſo laid, will give the altitude

tude required; if you count the degrees fro
F. Thus the ſun declining ſouth 11 *gr.* 3
will have $16\frac{1}{2}$ *gr.* of altitude in the 45 *Azi*
muth.

℄ If the ſuns declination be North, --
---and the *Azimuth* leſſe then 90 from ſouth
Count your *Azimuth* from E to S, and la
the threed at it, and let it cut E N, in T. The
ſet one foot of your former extent in T, and
with the other foot turned about, lay the
threed at the remoteſt diſtance, from T to
wards the ſide A C. The theed ſo lying, ſhew
from F in the equall limbe, the altitude requi
red. Thus if the ſun decline 11 $\frac{1}{2}$ *gr.* North
his altitude upon the 45 *Azimuth* will b
42 $\frac{1}{5}$ *gr.*----But if the Azimuth be more than
90, count from B to S, the exceſſe above 90;
and applying the thread thereto, ſee what de
grees of the equall limbe the threed cut
from From F. Count that number of de
grees from 60 (in the equal limbe) forwards
toward 70, 80, 90, and lay the threed there
which ſuppoſe to cut the line $a\ \omega$, in π. Se
your compaſſe (keeping ſtill their firſt extent)
upon π, and turn the other foot towards th
the ſide A C, laying the treed at the remoteſt
turne. If now to the threed ſo laid, you num
ber the degrees in the equall limbe, from

60 th

so, the same shall be the altitude required. Thus if the sun decline 11 $\frac{1}{2}$ *gr.* North, and the Azimuth be 101 $\frac{1}{4}$ *gr.* from South, the altitude must be 5 $\frac{3}{4}$ *gr.* in our latitude of 51 *gr.* 30 minutes.

Another way for this Proposition.

BY the first work in this 11th, get the Equinoctial altitude or depression for your Azimuth. Then lay the threed at E: and in C D, from D, count the said altitude or depression; from which number or point, take the least distance to the side A C. Enter this length between the side A C and the threed, keeping one foot upon the line A C, remove it thereon to and fro, till the other foot turned about may justly touch the threed. Then keeping your compasses there set, remove the threed from G toward H, according to the Suns declination, and take the least distance from your former standing to the threed. This length measured in the Scale C D [so as one foot standing upon the Scale, the other turned about may justly touch the side A C] shewes an arke, Which,

If the suns Declination be south, must be substacted from

If the suns Declination be north, and the Azimuth lesse than 90, must be added to

} the Azimuths Equinoctiall Altitude.

If the suns Declination be north, and the Azimuth more than 90, the Azimuths Equinoctiall depression must be taken out of this arke;

The result is the altitude looked for.

Thus if the Azimuth be $\frac{70}{110}$ from south the Equinoctiall $\frac{\text{Altitude}}{\text{Depression}}$ will be 15 ¼ degrees.

The arke found, will be 14 ¼. Then,

If the ☉ decline 11½ south, the altitude upon the 70 Azimuth wil be 1 degree.

If the ☉ decline 11½ north, the Altitude upon the 70 Azimuth will be 29 degrees.

If the ſuns declination were 20 *gr.* north, That forementioned arke would be 25 *gr.* whence taking $15\frac{1}{4}$, there remaines $9\frac{3}{4}$ for the Altitude of the ſun upon the 110 Azimuth from ſouth, at that Declination of 20 *gr.* north.

¶ By this worke, may a table of altitudes be made, by which the former Azimuth lines upon the quadrant may be inſerted.

XII. *To finde how high the Sun ſhall be at any houre, and in any Declination.*

FIrſt, finde the intercepted arke of your houre, betweene the parallel of Declination, and the Horizon, by the tenth.

Secondly, finde what angle your hour circle maketh with the Horizon, by the ninth.

Thirdly, count that angle from C towards D, and from thence take the leaſt diſtance to the ſide A C. Meaſure this length upon the ſide A C (from A) and there ſet your compaſſes. Then keeping that ſtation of your compaſſes, Lay the threed to the intercepted ark, counted in the equal limbe from G: and take the leaſt diſtance from your ſtanding to the threed. Set one foot of this length in the

ſcale C D, ſo, as that the other being turned about, may touch the ſide A C, ſo ſhall that foot in the ſcale C D, give the Degrees of Altitude required, if you number them from C.

Let the houre be three from Noon. The intercepted arke between the Equinoctiall and Horizon, will be 29 *gr.* 22 minutes. And if the Sun decline $\begin{matrix}\text{North}\\\text{South}\end{matrix}$ $11\frac{1}{2}$ *gr.* The intercepted arkes will be $\begin{matrix}40.52\\17.52\end{matrix}$. And the angle of the third houre with the Horizon, is 63 *gr.* 53. So that the Altitude for $\begin{matrix}\text{North}\\\text{South}\end{matrix}$ Declination of $11\frac{1}{2}$ *gr.* will be $\begin{matrix}36\\16\end{matrix}$ degrees.

¶ By this work you may make a Table of the Suns altitudes upon any parallel of Declination. And by thoſe altitudes you may inſert thoſe Summer and Winter houres which are upon the Quadrant.

XIII. *To finde the Suns Azimuth.*

FIrſt, lay the threed to the Suns Declination counted in the equal limbe from F to K, and take the leaſt diſtance from the point B

to the threed, and keep your compasses at that extent. Then count the Suns Altitude in the equall limbe, from F, and lay the threed to it. This being done,

¶ If the Sun Decline South, keep one foot of your compasses always upon the line E N, beyond the threed, towards E, and remove it still upon that line, till the other foot being turned about may touch the threed precisely. Observe then; where the foot of your compasse standeth upon the line E N suppose at V. Bring the threed to V, and it shewes (from E) the Azimuth from the South.

¶ If the Sun Decline North, keep one foot of your former extent, upon the line E N, on this side the threed, towards N, and remove it still upon that line, until the foot that is turned about do touch upon the threed. And observe where your compasse foot then standeth, upon the line E N (suppose it stand at W.) Lay the threed at W, and it will cut the scale E B. The parts whereof, from E to the threed, are the Azimuth from South.

But if it so fall out in North Declinations, that when the threed is laid to the altitude, you cannot finde roome upon the line E N, whereon to set your compasses so as to keep

the conditions before required; then work in this manner. Add alwayes 30 degrees to the Suns altitude, and lay the threed at that compound Altitude, numbred in the equall limbe from F. To the threed so laid, enter the former extent of your compasses, between the threed and the line $\alpha \omega$, keeping one foot alwayes upon that line. And look where the foot of your compasses resteth upon that line; suppose at π. Take then the length from π to α, and set it upon the line N E (from N towards E): and to the point where it rests, apply the threed: observing what parts it cuts upon the scale, from B. The number of those parts, gives the quantity of the Azimuth above 90 from the South. Or the parts cut from E, give the Azimuth from the North.

☞ If the ☉ decline not at all, but is in the Equinoctiall, then the sole Altitude from F to K (by helpe of the threed thereto applied) gives E S the Azimuth from South.

If the Altitude of the ☉ be 21 $\frac{1}{3}$ in the Equinoctiall, the Azimuth from South is 60 degrees.

If the Sun decline South 5 *gr.* and the Altitude were 15 $\frac{3}{4}$ *gr.* the Azimuth would be 60 degrees.

If

If the ☉ decline North 10 *gr.* and the Altitude were 50, the Azimuth would be found 50 *gr.*

If the ☉ decline North 20 *gr.* and the Altitude were $9\frac{3}{4}$ *gr.* the Azimuth would be 110 *gr.* from the South.

☾ If you suppose the sun to have no Altitude, and do work by these rules, you shall finde the suns Amplitude, Ortive and Occasive, from the South. As if the sun Decline 20 *gr.* North, you will finde 123 *gr.* 20 *min.* for the Amplitude from the South.

XIIII. *To finde the houre of the day, by the Sun.*

COunt the suns Altitude in the equall limbe from F: and to the threed there laid, take the least distance from the point B: and keep this distance.

Then count the suns Declination (which is had easily by the first proposition:) from F in the equall limbe, and apply the threed, to it. Then further,

☾ If the declination be South, set one foot of your former extent, upon the line E N (alwayes

wayes on that ſide the threed on which E ſtandeth from it) and remove it thereon, till the other (turned about) may juſtly touch the threed A K. Suppoſe (in ſo doing) the compaſſe foot ſtayeth at V. The threed applied to the point V, will cut the houre from Noon, if you count the intercepted parts upon E B, from E. —— Thus if the ſun decline 20 degrees South, and the Altitude were 13 *gr.* 50 *min.* the houre at *London* would be 10, or 2.

¶ If the Declination be North, ſet one foot of your former extent upon the ſide A C, removing it thereon to and fro, till the other foot turned about, will onely touch the threed. When it is ſo fitted, let that foot upon the ſide A C, keep its ſtation; and from thence extend the other foot to the ſuns Declination counted in the ſcale A P This laſt extent muſt be applied to the line N E, from N: and where it ſtayes, lay the threed. So the parts cut upon the ſcale E B, will give the houre. —— But this muſt be done with caution For if that foot that kept its ſtation, ſtood from A, beyond the Suns Declination in the ſcale A P, then the intercepted arke from E to the threed, gives the houre from Noon. But if the forenamed foot ſtood between

tween A and the Declination, then the whole arke E B 90, with the arke from B back again to the threed (these two put together) give the hour from Noon.

Thus, if the sun decline 15 *gr.* Northward, and be 21 *gr* high, the houre is 7 before, or 5 after, Noon. Or if the altitude were $2\frac{2}{3}$ *gr.* the houre must have been 5 in the Morning, or 7 in the evening: namely, 90 and 15 degrees from Noon.

XV. *On an Upright declining plane, to finde the angle betweene* 12 *and* 6.

COut the palnes Declination from C towards D: From that point take the least distance to the side CA. Set that length from M to Y, upon the line M Y. The threed laid at Y gives G K for the angle betweene 12 and 6.

Or count the Declination of the plane from B towards E, and lay the threed at it. The threed will cut N E. Take from N to the intersection, and apply it to M Y; the threed put to Y gives G K, as before.

If a plane Decline 20 *gr.* this angle will be $66\frac{3}{4}$ at *London.*

XVI. *To finde the Declination of a plane.*

FIrſt, draw an Horizontall line upon your plane (which you may do by your quadrant.) Then apply one ſide of the quadrant to that line, ſo as the limbe may be toward the ſun, and the plane of the quadrant may lye Horizontally flat. Thirdly, having a looſe threed and plummet, you muſt hold that threed cloſe by the edge of the limbe (letting the plummet hang down at liberty) till the ſhadow of the threed paſſeth directly through the quadrants center. Which done, you ſhall ſee what degrees of the limbe the ſhadow cuts from that ſide of the quadrant which is perpendicular to the Horizontall line. This is called the Horizontall diſtance. At the ſame moment of time, obſerve the ſame Altitude. By this Altitude you may get the ſuns Azimuth from South, by the thirteenth.

After this preparation, take diligent notice, whether the ſhadow of the threed fall betwixt the South and the perpendicular ſide of the quadrant, Or whether the ſame ſhadow fall

fall ſo, as to leave both the South and the ſaid perpendicular ſide (both of them) upon one coaſt of the ſhadow.

In the firſt caſe, you muſt add the Horizontall diſtance to the Azimuth. In the latter caſe, you muſt ſubſtract the leſſer out of the greater. The reſult (whether it be ſumme or difference) gives the planes Declination from the South.

Note here in the ſecond caſe. That if the Horizontall diſtance be greater then the Azimuth, then doth the plane decline to that coaſt (Eaſt or Weſt) which is contrary to the coaſt on which the ſun ſtood from the South. This falleth out very frequently.

Note alſo in the firſt caſe. That if the ſumme of the Horizontall diſtance and Azimuth do exceed 180 *gr.* then the planes Declination from South, is contrary to that coaſt whreon the ſun ſtood. And it is found, by ſubſtracting the forementioned ſumme out of 360 degrees. This happens more ſeldome: that is, onely upon ſome North planes; and on them, onely then, when the ſuns Azimuth is more than 90 from the South; and the Horizontall diſtance more than is the Azimuth from the North.

Examples are here omitted for brevities ſake.

ſake. Onely add this. That if the planes Declination from South be above 90 *gr.* you muſt ſubduct it out of 180, and the remainder is the Declination from the North. ——By this accounting from North and South, you may always make that your plane decline not above 90. And as when it declines nothing it is a full South or North plane; So if it decline juſt 90, it is then a full Eaſt or Weſt plane.

XVII. *How to draw any upright declining Diall.*

FIrſt, draw a perpendicular or Plumb-line A B, and croſſe it at right angles with the Horizontall line B C: and make B A equall to A ⊙ in your Quadrant.

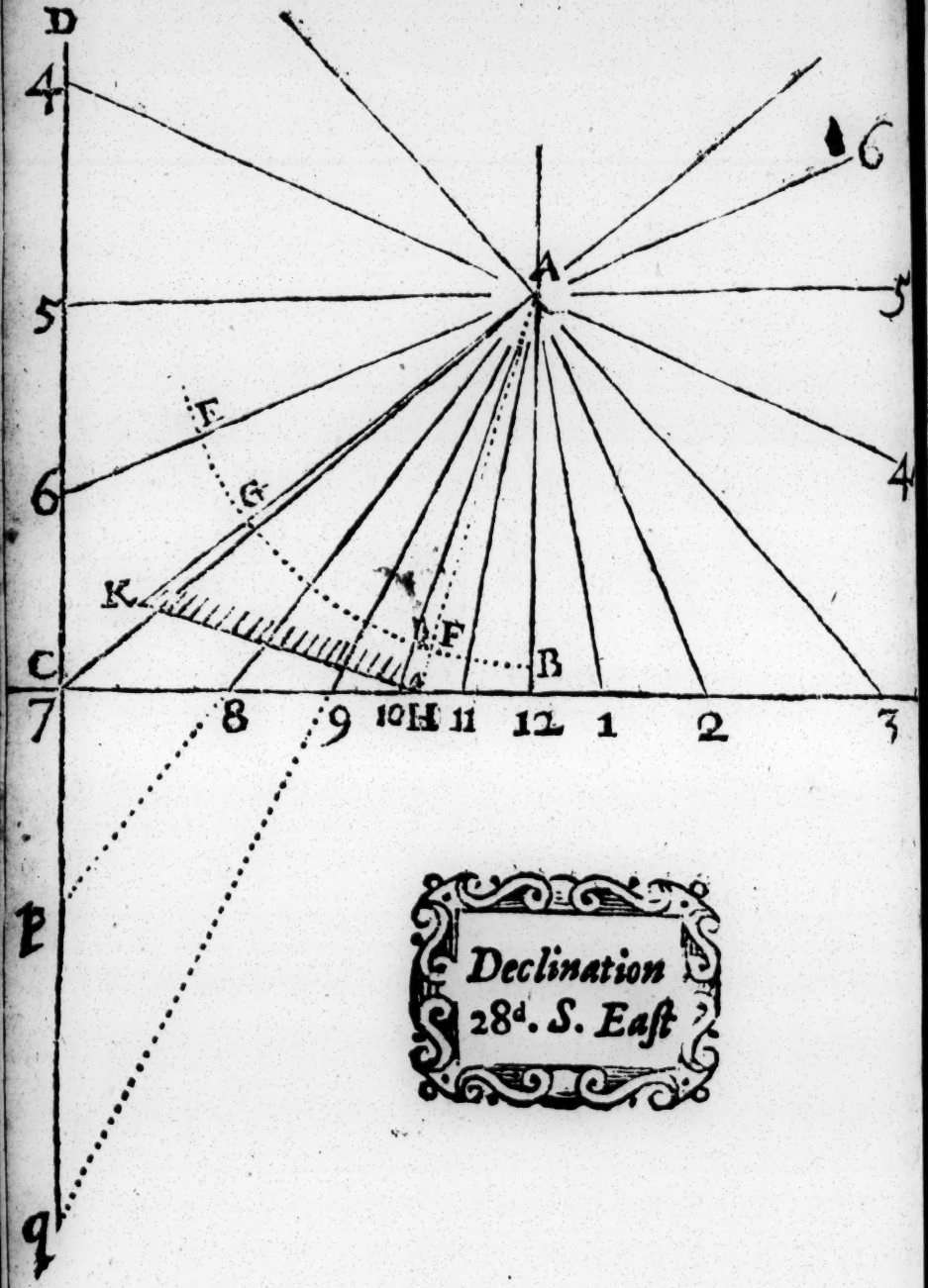
2 Upon the equall limbe of your Quadrant, count the planes declination (from North or South) from G, and there keep the threed: which will cut ſome of thoſe lines that are drawn within the upper ſquare.

3 Obſerve firſt, thoſe interſections which the prickt lines make with the threed at *b*, *d*, *m*. ——Take then the length from A the center of the quadrant to *b*; and ſet it here upon the Ho-

Horizontall line from B to 1, (always on that ſide of B, which looks to the ſame coaſt whereunto the plane declineth.) So, take from the quadrants center A, to the ſecond prickt lines interſection with the threed, at *d*; and ſet it here from B to 2. So likewiſe the third A *m*, muſt be ſet from B to 3.

4 Obſerve again all ſuch interſections as are made with the threed, by the reſt of thoſe lines whoſe common concurrence is in the point M, namely, at *a*, *c*, *e*, *b*: and take their ſeverall lengths from the quadrants center A, and prick them here down on the other ſide B (contrary to the coaſt of declination) namely, at 11, 10, 9, 8. Then for the next line upon the quadrant (which doth not, but would interſect the threed, if it were drawn out far enough) obſerve where the threed cuts the extravagant line *r s*, namely, in *s*: and take from A to *s*, and turn that length twice from B, ſo ſhall it deſigne the point 7. Afterwards at the point 7, draw the infinite line C D parallel to B A. Alſo ſet off the houre of 6, on that ſide B which is contrary to the coaſt of Declination, namely, from B to E, according as the angle between 12 and 6 ſhall be found by the fifteenth.

5 Draw all the houre-lines from A, the center



Declination
28d. S. East

B A = A O in quadrant the Last

B 1 = A b to Coast of Destination

B 2 = A d

A M = B 3

A a = B 11

A C = B 10

A e = B 9

A h = B 8

The point X is so sitted y
if AB = AO on the quadrant to tangent of y latitude
AX shall be [illegible]

center of your Dial, through the points 3, 2, 1, 12, 11, 10, 9, 8, 7, in such wise, that as many as well can, may cut the line D C, as is here done, in *p* and *q*.

6 Make 6,5, equall to 6, 7: and 6,4, equall to 6, *p*: and 6, 3, equall to 6, *q*: and draw the rest of the houres, *A* 5, *A* 4, *A* 3. Thus you may get 12 houres, and if you extend them beyond the center, you shall have the whole 24. Out of which you may make choice of such as will serve your use.

¶ *For placing the style,*

Seek the Elevation and Deflexion by the fifth and sixth. And make B F equall to the Deflexion, setting the substylar line F A always on that side 12 which is contrary to the coast of the planes declination. Make also F G equall to the Elevation: So F A G will be the pattern of the style.

Or the threed lying still at the planes declination upon the Quadrant as it did, Take the least distance from the point X to the threed, and set that length from B to H, and draw A H for the Substylar. Then making A H K a right angle, take the least distance from M to the threed, and make H K equall to this distance: So is K A H the pattern of your style.

¶ *In*

¶ *In all Dials,* The ſtyle muſt ſtand juſt over the Subſtylar, Elevate ſo much above it, as the Elevation (befor found) commeth to.

In South Upright decliners, the center of th Diall is above (as in the former figure) an the ſtyle points downward. But in North de cliners, the center muſt be below, and th ſtyle muſt point upward.

XVIII. *Of the upright full South-Diall.*

THe Declination of the full South Diall i nothing. Whence it is, that

The angle betweene 12 and 6 is 9 degrees.

The line of 12 is the ſubſtylar.

The ſtyles Elevation is the comple ment of your latitude.

The way of pricking down the houres i (in a manner) the ſame with that befor for decliners. No more needs to be ſai of it.

The Erect full North plane is the ſam with this South. Onely the ſtyle of this points upwards toward the North pole, a the former doth downward towards th South pole.

XIX O

XIX. *Of Upright far declining plaines.*

THeſe Dialls are more difficult than thoſe other decliners mentioned in the ſeventeenth, becauſe here the houres have no center or point of meeting upon the plaine. It will not be amiſſe therefore to ſet down the whole worke in all parts of it.

1 Draw a perpendicular or plumb-line A B, and croſſe it at right angles with the Horizontall line B C. And make B A equall to A ⊙ in your quadrant, ſetting A above B if the plaine decline from the South, or below B if it decline from North.

2 Count the plaines Declination from South or North, upon the limbe of your quadrant, from G: and there keep the threed.

3 Among thoſe lines on the Quadrant (whoſe common concurrence is at M) obſerve that interſection which is made by the 6th houre from the quadrants center, with the threed. Take the length from the ſame center to that interſection, and prick it down here from B to C (and on that ſide B which looketh toward the South, if the plaine decline from South: or toward the

North, if the plaine decline from North.) And draw out the lines C D E parallel to B A.

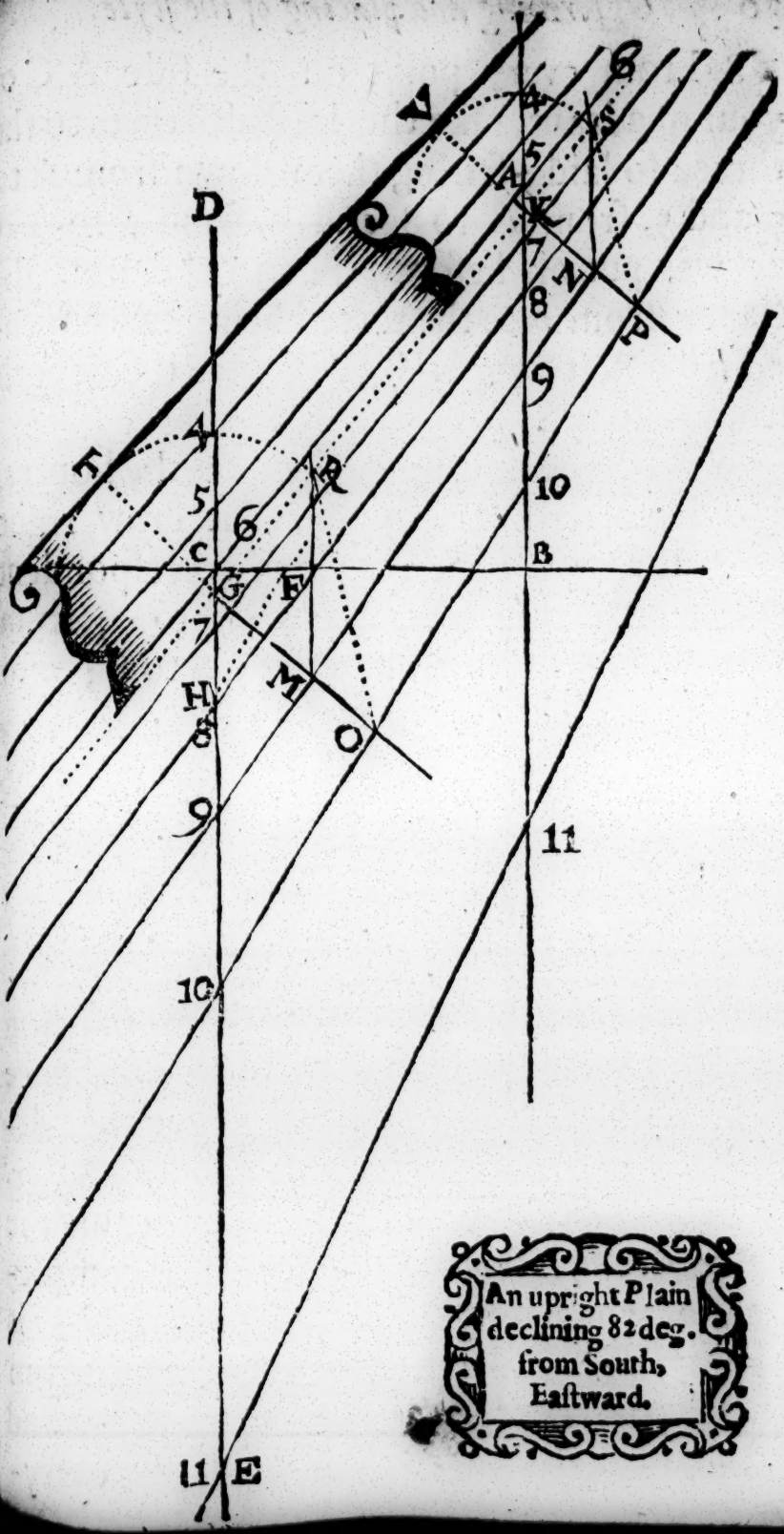
4 Obſerve again upon the quadrant that interſection which the ſecond line from the the center makes with the threed, and take the length from the center of the quadrant thereunto, and prick it down towards C, namely from B to F.

5 Take the lengths from the center of your quadrant to every houre point upon the ſide A C: and prick them all downe here, from C to 7 and 5, from C to 8 and 4, from C to 9, 10. And laſtly, take from the center of your quadrant to the point *r*, and turn that length twice from C: this double length will reach from C to 11, at E.

6 Lay a ruler to A and F, and transfer the the point F unto H in the line C E. Then take the length from H to 10, and ſet it from A (towards B) to 10, the ſame way from A that 10 ſtands from H.

7 With the ſame length H 10, or A 10, go to your quadrant, and ſetting one foot of it, on the ſide A C, in the fourth point from the Center, with the other (turned about) lay the threed at the remoteſt diſtance, and keep it there.

8 From



An upright Plain declining 82 deg. from South, Eastward.

8 From every point on the ſide A C of your quadrant, take the leaſt diſtances to the threed ſo laid; ſetting them down from A to 7 and 5, from A to 8 and 4, from A to 9. A 10 was put on before. Then the leaſt diſtance from *r* to the threed being twice turned from A towards B, will give the length from A to 11.

9 For the finiſhing then of the houres, you have no more to do, but draw right lines through each couple of correſpondent points; namely, from 4 to 4; 5 to 5; from C to A, or 6 to 6; from 7 to 7; 8 to 8; 9 to 9; 10 to 10; and from 11 to 11.

ℂ *Concerning the forming and placing of the ſtyle.*

10. BY the precedent ſeventh propoſition you may finde the plaines difference of Longitude, which (for this plaine that declines 82 *gr.*) will be (here at *London*) 83 *gr.* 43 *min.* and that from the South, becauſe the plaine declines from the South. The complement of which longitude (83 *gr.* 43 *min.*) is 6 *gr.* 17 *min.* Take then firſt, the length from C to 7 the next hour point upon C E, and carry-

carrying that extent to your quadrant, ſet one foot of it upon 15 in the ſcale A P: and lay the threed ſo, that the other foot turned about may juſt touch or paſſe over it: and keep the threed there. Then (in the ſcale A P) count the forementioned complement, *6 gr. 17 min.* and taking the leaſt diſtance from that point to the threed, ſet it from *6* a clock at C, towards E if the plaine decline from South, (or towards D if the plane decline from North) as you ſee it done here, at G. Secondly, do the ſame worke again upon the line A B. That is; Take from A to 7 the neereſt houre point, and ſet one foot of that extent upon 15 in the ſcale A P, and with the other foot turned about, lay the threed as before. Then in the ſame ſcale A P, count the ſame number *6 gr. 17 min.* and taking the leaſt diſtance from thence to the threed, ſet that length from A to K, anſwering to C G. And laſt of all, draw the right line G K. This ſhall be the line of deflexion, over which the ſtyle muſt ſtand.

11 Furthermore. Through the points G and K (or any other two points of the ſame line) draw the two lines G O, K P, both perpendicular to the deflexion line G K. Then conſidering that every houre comprehends 15 degrees of longitude (that is, that from C to 7

is 15, and from 7 to 8 is 15, &c.) and since that C G is 6 *gr.* 17 *min.* If C G, be taken out of C 7 which is 15 *gr.* there will remain G 7, 8 *gr* 43 *min.* To which, if you add from 7 to 9, which is two houres or 30 degrees, the sum will be 38 *gr.* 43 *min.* whose complement is 51 *gr.* 17 *min.* If now you make the angles G M R, and K N S, each 51 *gr.* 17 *min.* they will cut the Deflexion line G K, in R and S. And if further, to the radius G R, you describe the arke R T; and to the radius K S you describe the arke S V; and draw the line T V, a tangent to both these arkes, the *Trapezium* G T K V shall be the pattern of your style. In placing which, you must be carefull that these perpendicular lengths G T and K V (perpendicular I say to T V the Fiduciall edge) be justly placed upon the two assumed points at G and K. ——Or having found G 7 to be 8 *gr.* 43 *min.* you may add to it from 7 to 10, which is (three houres or) 45 degrees. The summe will be 53 *gr.* 43 *min.* whose complement is 36 *gr.* 17 *minutes.* If now from the points O and P (where the said houre of 10 cuts the two fore-mentioned perpendiculars G O and K P) you make the angles G O R and K P S, each equall to 36 *gr.* 17 *min.* they will cut the deflexion line G K in the

the ſame two points R and S. After which, you may proceed to make the patterne of your ſtyle, as before.

℄ 1 Note that in performing the fifth ſection of this propoſition, inſtead of taking thoſe houre points from the Center of your quadrant upon A C the ſide of your quadrant (if thoſe diſtances ſhould be too great for your plaine) you may lay the threed any where upon the Quadrant, and inſtead of taking from the center to the fore-named points, you may take the leaſt diſtances from the ſaid points to the threed, ſeverally, and ſet them down from C to 7 and 5, and from C to 8 and 4, and ſo to 9, 10; and for 11, you muſt take from the point *r* to the threed, and ſet it twice from C; by which meanes they will all be of leſſe diſtance from C. And then all the worke is to be continued, as is before preſcribed. ——Or if the ſaid diſtances ſhould be too little, you may double, triple, or, &c, to make them greater.

℄ 2 Note again, that in decliners from the North, that difference of Longitude

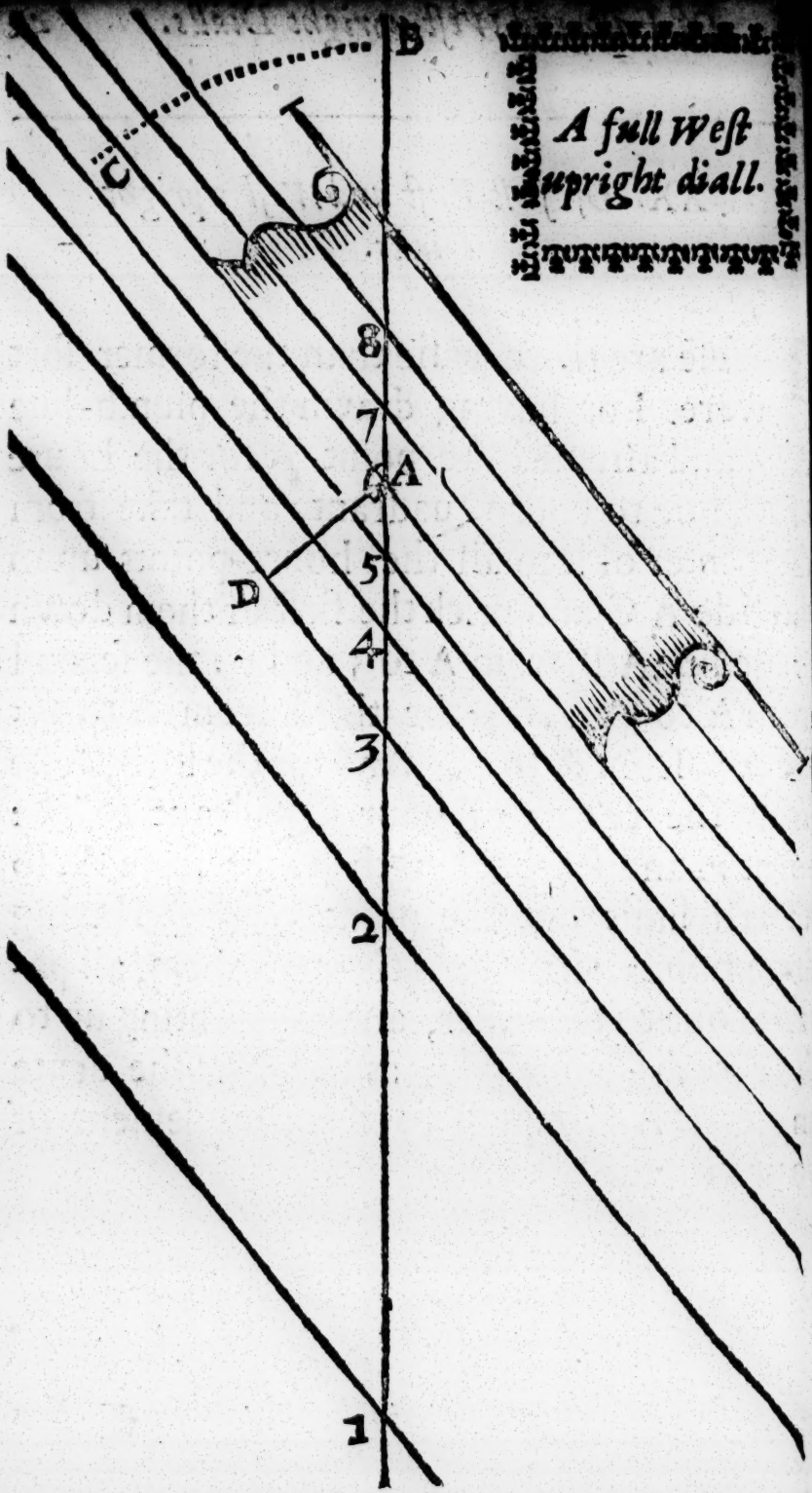
gitude which you finde by the ſeventh, is to be reckoned from the North, and ſo the complement of it is to be accounted from C (or 6 a clock) towards **D**. And that the wideſt parts of the houres in theſe North plaines muſt point upwards, and the cloſeſt parts downwards; contrary to what is expreſſed here in this plane, which hath its Declination from the South.

☾ 3 Note laſtly, that this direction here given for enlarging the houres in farre Decliners, may eaſily be applied to ſuch direct, or Horizontall Dials (as are mentioned in the 26 following) upon which the pole hath but ſmall Elevation. For the Diall (or onely ſome chief houres of it) being deſcribed in its naturall ſtreightneſſe, may be enlarged by the ſame meanes that this laſt was. Which will not be hard to do, but would be tedious here to run over againe.

XX. *Of*

XX. *Of full East and West upright Dialls.*

THese are more easie than the former sort were. For having drawn the plumb-line A B, and assumed the point A for the houre of 6; goe to your Quadrant, and take from the center of it to all the houre-points upon the side A C; and prick the first of them down in the line A B, from A to 5 and 7: the second from A to 4 and 8; the third from A to 3: the 4th. from A to 2. And for the fifth, Take from the center of your Quadrant to the point *r*, and set that length twice from A, so it shall limit out the point 1. —— Having these points, draw lines through them, all parallel one to the other, and all pointing up to the North; namely so, as to make the acute angles B A C equall to the complement of your latitude.



A full West upright diall.

As Radius to ~~Cosine of~~ Rectangular
Declination So tang^t of the
Latitude, So tangent of the
Substilar from the meridian

As the Radius to Tangent of
the Latitude So Sine of
Declination to Tangent of the
Tangent

As Radius to Sine of Declination
So Sine of the Latitude
To Sine of the Sides wright
Or
Tangent of the Latitude to Cosine
Inclination of meridians
So Radius to Tangent of the
Side wright

☾ *For the Style.*

IT muſt always ſtand over the line of *6* a-clock, parallel to it, and diſtant every where from it according to the length of **A D**. Which lenght is ſoone found, by drawing **A D** perpendicular to the houre-lines, cutting the third houre from *6*, in **D**. By which line you may make the patterne of your ſtyle. For the Fiduciall edge lyes parallel to the line of *6*, **A C**, and at the diſtance of that line **A D**.

☾ 1 Note here too; that if your lengths from the Quadrants center to the houre-points be too long, you may ſhorten them by laying the threed upon the Quadrant according as your convenience ſhall direct, and taking the leaſt diſtances from thoſe houre-points to the threed; and ſo pricking them on from A or *6*, to *5*, *4*, *3*, &c; as was before mentioned in the firſt Note upon the former propoſition. —— Or if they be too little, they may be doubled, &c. as is there expreſſed.

☾ 2 Note

¶ 2 Note further, that what is here done for deſcribing theſe Eaſt and Weſt Dialls, may be applied to the direct Polar Plaine. Onely remember that you are not tyed (in the Polar) to make the houres to any ſet angle with the line B A, but they are beſt at right angles; for then the line A B may be taken for, and placed as, the Horizontall line of the ſaid plaine; all the houres lying as verticall lines unto it. And alſo the line of 6 here, muſt be taken (in the direct polar) for the line of 12, and the reſt of the houres are to be drawn alike on both ſides 12: nothing in ſubſtance differing from theſe Eaſt and Weſt Planes.

XXI. *In Eaſt and Weſt re-in-cliners, To get the Deflexion.*

COunt the re-in-clination from D towards C. Take the leaſt diſtance from thence to the ſide A C. Set that lenght from

from M to Y, and lay the threed at Y. The degrees F K will give the Deflexion.

The ſubſtylar line muſt aſcend in Recliners, and deſcend in Incliners, from the line of 12, according to the quantity of this Deflexion.

The line of 12 lyes always Parallel to the Horizon.

XXII. *To finde the angle Between* 12 *and* 6.

COunt the Re-in-clination From E towards B. The threed there laid will cut the equall limbe. The degrees whereof from G to the threed, are the angle required.

XXIII. *To get the Styles Elevation.*

LAy the threed to the Re-in-clination numbered in the equall limbe from F, and take the leaſt diſtance from N to the threed. Set one foot of that length in B, and lay the threed ſo as to touch the other foot when it is turned about. The threed ſo laid, gives the Elevation in the equall limbe, from F.

XXIV. *To finde the difference of Longituae.*

1 COunt the Deflexion in the equall limbe from F, and lay the threed to it; and take the leaſt diſtance from B to the threed. Put one foot of this length in N, and apply the threed to the remoteſt diſtance of the other foot. The threed will then ſhew in the equall limbe, the difference of longitude, if you count from F.

2 Count the deflexion in the equall limbe, from G: and to the threed there laid, take the leaſt diſtance from B. Meaſure that length upon the ſide A B, from A; keeping one foot there fixed. Then lay the threed to the plaines Re-in-clination counted alſo from F in the equall limbe, and take the leaſt diſtance from your ſtanding to the threed. Set one foot of this length in B, applying the threed to the other foot turned about. The threed ſo laid, gives the difference of Longitude in the equall limbe, from G.

Thus if an East or Weſt plaine Re-incline, here at *London*, 30 degrees, it will have in De-

By Substitute distance.

As the Cosine of the Latitude
to Cotangent of Declination from
the Zenith so Radius to the
tangent of ye Inclination of
Meridians

Deflexion ——— 47°. 26′.
Angle from 12 to 6.---55. 26.
Elevation ——23°. 02′.
Differ.of long.--70. 14.

XXV. *How to draw the Diall.*

VPon the backside of your Quadrant, in the upper part of it, you have lines drawne altogether like those on the foresaid placed neer the Quadrants center, the use of which was shewed before.

The manner of work in this proposition is in most things sutable to that in the seventeenth, and will need no other direction.

Onely for placing the lines, Take notice, that,

The line of 12 in these East and West Re-in-cliners, lyeth alwayes parallel to the Horizontall line of the plaine. So that if we suppose the former figure of the seventeenth to represent one of these Dialls, then A B must be conceived to lie Horizontall, and B C verticall. All other works will be like to those in the seventeenth.

The style in recliners pointeth upward, and the substylar and houre of 6 do ascend above the

the line of 12, So much as the Deflexion and angle from 12 to 6, come to. The center of the Diall is on the South end of the line of 12.

The ſtyle in incliners pointeth downward, and the ſubſtylar and houre of 6 do deſcend below the line of 12, ſo much as the Deflexion and angle from 12 to 6 come unto. The center of the Diall is on the North end of the 12 a clock line.

Theſe things being obſerved, you muſt count the Re-in-clination of your plaine in the equall limbe on the backſide from the left hand toward the right, according as the figures are ſet: and there lay the threed and keep it. Then obſerve how it cuts the lines next to the center, and proceed in all things as in the ſeventeenth before.

℄ Note that you may finde the inclinatio n of a plaine by applying one ſide of your Quadrant to the plaines verticall line: for ſo the threed will cut the quantity of inclination in the degrees of the equall limbe being numbered from that ſide of the Quadrant which toucheth the plaine.-----And for finding the reclination, yon may lay a ruler to the verticall line of the reclining face, and take the inclination of the under ſide of that ruler.

That

hat inclination will be the ſame with the re-linination.

Note alſo, that this here delivered for Eaſt nd Weſt Re-in-cliners, is intended chiefly for drawing houres upon thoſe kindes of laines when you meet with them upon Bodies cut regularly. For otherwiſe you will ardly ever finde any ſuch juſt plaine upon fixed building.

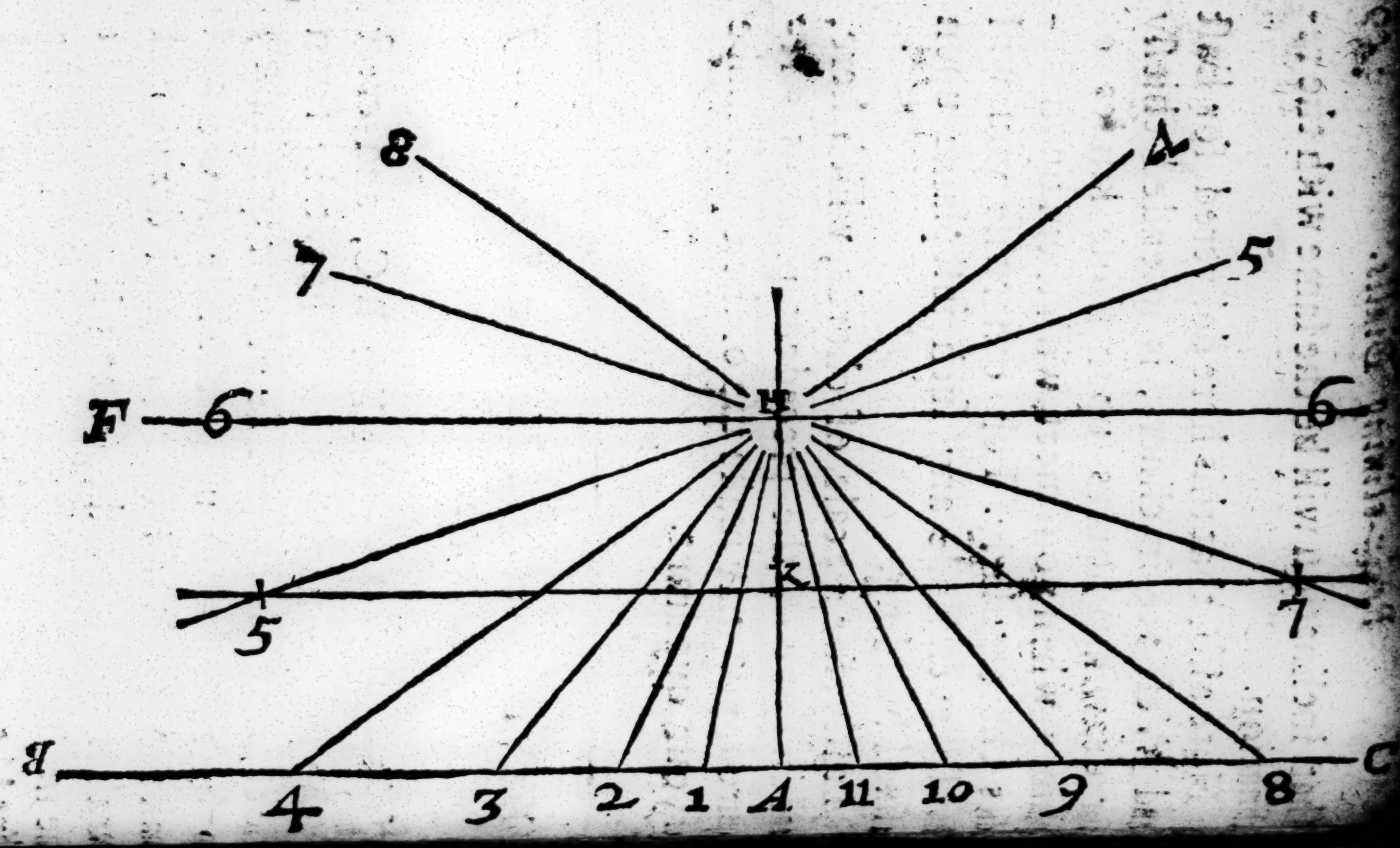
Laſtly, for a Scale of chords, which here, nd in ſome of the precedent precepts is required, you may make uſe of the equall limbe f your quadrant.

XXVI. *To make an Horizontall Diall to any Latitude.*

Irſt, draw the right line B C, and erect the Perpendicular A H. Then take from e center (on either ſide of your quadrant) the third houre upon the ſide A C; and ake A H equall thereto. And draw F H arallel to B C; and the line 5 K 7 alſo juſt in e midſt of them. —— After this, lay the reed to the Latitude of the plaine counted the equall limbe: and take from every oint of th ſide A C, the leaſt diſtance to the

E threed

123290M


8
4
7
5
F
6
E
6
K
5
7
B
C
4
3
2
1
A
11
10
9
8

threed, and ſet each of them down both wayes, namely, from A to 4 and 8, from A to 3 and 9, to 2 and 10, and from A to 1 and 11. Then take from the point *r* upon the ſide A C, to the threed, and ſet that length from K to 5 and 7, both wayes. —— You have now nothing more to do, but onely from H to draw the hour-lines to all the forenamed points: ſo the draught is eaſily finiſhed.

The ſtyle muſt ſtand upon the line of 12, and is to be elevated according to the plaines latitude: as the manner is in all Horizontall Dialls.

¶ The uſe of this propoſition is to draw all Dialls in any Latitude for any direct re-in-clining plaine. For, the re-in-clination compared (in North re-in-cliners) with the poles Elevation: or (in South direct re-in-cliners) with the Equinoctialls Altitude, will eaſily give the plaines Latitude: in the former, the difference was the Elevation it ſelfe: in the latter, the Complement of the poles Elevation.----And this propoſition, with the ſeventeenth for upright plaines; the twentieth for upright Eaſt and Weſt, and ſo alſo for Polar plaines on which the pole hath no Elevation: the twenty fifth for Eaſt and

Weſt re-in-cliners: the eighteenth for full North and South erect; will furniſh you with wayes to draw Dialls upon ſuch regular bodies, whoſe plaines have any ſuch of the fore-mentioned Aſpects.

XXVII. *To finde the houre of the Night by the Starres.*

THe Stars upon the Quadrant (one or other of them) will alwayes be in convenient place of the heavens: that is, of two or more houres diſtance from the Meridian.——Having then made choice of that Starre that is fitteſt, looke what number is annexed to the name of it. Seeke that number in the left margin of the foreſide of your quadrant, and cloſe by the houre lines, and rectifie the Bead to it.——Then hold up the quadrant ſteadily, with the ſights levelled to the Starre, as if you were to take the Starres Altitude: and you ſhall finde the Bead to ſhew (among the Summer houres of the quadrant) the motion of the Starre in houres, quarters, and parts of a quarter

a quarter. This is called the Starrs houre; but this is not the houre of the Night till it be turned into the Suns houre: which thing is to be done in this manner

Look upon the back-ſide of the quadrant for your Starre, and lay the threed upon it: ſlipping the Bead down to the ſlope-houres below, till it ſtand upon the ſame quarter and part (from ſome juſt houre on the left hand of the bead) with the Starres houre before found. Then note the ſaid houre on the left hand which goeth next before the bead, for that muſt be ſuppoſed to repreſent the Starres houre, and muſt therefore be called by the ſame, or number that the Starres houre was. And following houres (from the Bead towards the right hand, muſt ſucceſſively take their numbers, untill you come to be under the day of your moneth. Unto which day if the threed be layd, the bead will (by keeping your former account) ſhew the true houre, quarter, and part, of the Night.

Example, 1. On *January* the 20, the hour of *Cor Leonis* was obſerved Eaſtward of the Meridian, to be 9 and $\frac{1}{4}$ and $\frac{1}{3}$ part a quarter. The threed laid upon that Star, on the back-ſide of the Quadrant, will croſſe the ſlope houres as doth the line A B. And the bead put

down to the forementioned parts of the houre, will ſtand at the point B. So that the hour C muſt be called 9 a clock, which is the obſerved houre of the Starre. Then the line D muſt be called 10 a clock: and the threed being put to *January* 20 (taken in the lower circular line of moneths) will lie in the line A E; and the Bead at E ſhews the time of the Night to be paſt (the line D, that is, paſt) 10 a clock, about $\frac{1}{4}$ and $\frac{1}{3}$ part of a quarter, which is 15 and 5 *minutes*: or 20 *minutes* paſt 10 at night.—But if this obſervation had been upon the ſecond day of *November*: then the threed layd upon (the day given in the lower circle of moneths) *November* 2, would lie in the line A F: and the Bead would be upon the full houre-line that paſſeth through F, which would be 4 a clock in the morning For if the line C be 9, the line D is 10, the next line is 11, and ſo forward till your account fall upon F: which muſt be 4 a clock paſt (12 or) Midnight.

Example 2. Upon the 8 of *Auguſt*, the Starre *Aquila* was ſeen on the Weſtſide of the Meridian, and the houre of it was found, 3 and $\frac{1}{2}$ an houre and $\frac{1}{2}$ a quarter. The threed therefore being laid upon that Starre would

would be as the line A G, and the Bead (rectifyed to the $\frac{1}{3}$ houre and $\frac{1}{4}$ quarter) would ſtand at the point G. So that the next houre-line on the left hand of G, muſt be called 3 a clock: and the line F muſt be 8 a clock. Then, the threed being removed to the day of your moneth (*Auguſt* 8, in the upper circular line of moneths) will lye in the line A B: and the Bead at B will ſhew the houre of the Night (if you keep your former account) to be $\frac{1}{4}$ and halfe paſt 1 a clock. For if F be 8 a clock (as is before expreſſed) then the laſt houre of the limbe is 11, the firſt is 12, the ſecond 1; beyond which, the Bead B is about 22 *minutes* of an houre. Therefore the houre of the night is 1 a clock 22 *minutes*.

By theſe examples the manner of the worke will ſufficiently appear in all caſes.

The

The vſe of the Altimetrie Scale.

THat Scale on the fore-ſide of the Quadrant next to the equall limbe is here called the Altimerie Scale. It is numbred by 1, 2, 3, &c, to 10, 20, 30, &c, to 100. Each of which numbers are beſt ſuppoſed to be 100 fold. *viz*, 100, 200, &c, to 1000, 2000, &c: to 10000: and all the leſſer parts eſtimated accordingly. ——The ground on which you ſtand to make your menſuration, is alſo ſuppoſed to be a juſt levell.

I. *To finde any height at one obſervation.*

LEt your ſtation be at E; and the ſights D A directed to the point F: the threed A B cutts off the parts C B in the meaſuring Scale: which parts muſt be remembred. ——Then meaſure from your ſtation E, to the point H, which is juſt under F. And (alwayes in this caſe (multiply this diſtance E H by

As 1000 to the parts of the
quadrat
So the distance to the height

Example

To find part of an Altitude
first find the worke Altitude
& the higher part and then the
Altitude of the lower part and
Substract from each other

Look what to the next parts
being the bredth to the comp of
ye Angle it hung at and find
what part it cuts in the quadrat
Then as 1000 to the height
So the parts of the quadrat
to the distance

E H by the forenamed parts of C B, and from the product cut off 3 figures toward the right hand. The remainder is the Altitude G F. To which you must add H G, or D E, the height from your eye at D to your foot at E.

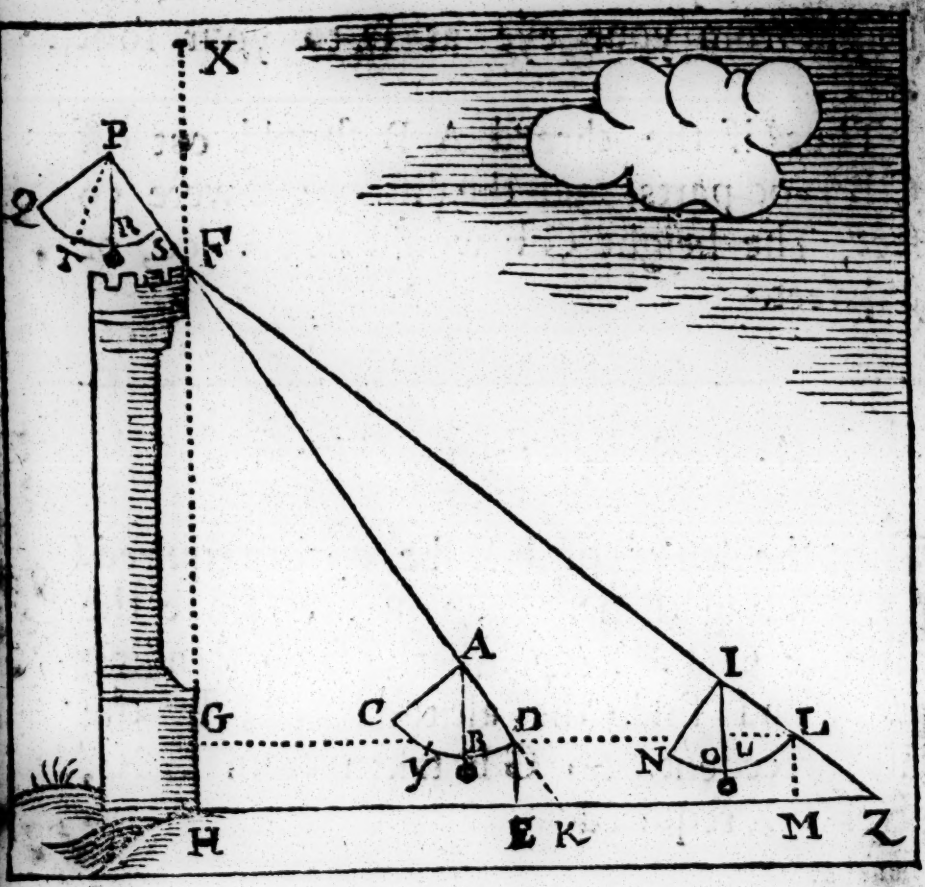
Thus if the threed A B should cut off C B 1500 parts, and the distance E were 59 feet, The height G F would be 88. 500, or $88\frac{1}{2}$ feet.

II. *To finde part of an Altitude.*

LEt the length of F X be onely required. Standing then at E, you may finde the altitude G F. Keep still the same standing at E, and finde the altitude G X, by the last precedent. So G F taken from G X, gives F X required.

III. *Standing upon a known height, to finde a Distance.*

LEt the height F H be known, and the distance H K be required. Order your standing so, that the two sights P, S; the point F, and the distance K, may all appeare in one right


X
P
Q
R
S
T
F
A
I
C
D
G
B
y
N
o
u
L
H
E
K
M
Z

for both the distances and subste
one from the other

Get the angles of the two
Altitudes in the Limbs and
then the Radius is to be brought
to that Compass and observed
what parts are cut in the
quadrat for the difference of
those parts by Substraction
from 60

The difference of those parts
is to the distance between the
two Stations So is 1000
To the Altitude

38 2/3 Comp 51 1/3 Tang 1250

56 1/3 Comp 33 2/3 Tang 667

Diff. 583

Distance of the Stations 51,6

583 : 1000 :: 51,6 : 88,5

583) 51,6000 (

4664

4960

4664

2960

2915

ght line. Then look what degrees the plummet cuts off in the equall limbe from Q. ount the ſame number in the ſame limbe, m S; and there lay the threed, as P T. Note en, what parts it cuts upon the meaſuring le from Q to T. Multiply thoſe parts in- H the known Altitude: and from the duct cut off three figures, the remainder or otient, is the diſtance H K.

Thus, if the threed P R ſhould cut off R in the equall limbe $56\frac{1}{3}$ degrees, the me counted the other way, from S to T the equall limbe, and the threed laid thereto, would give 667 in the meaſuring Scale. Then F G being $88\frac{1}{3}$ feet, and G H (ſuppoſe) e feet, F H muſt be $93\frac{1}{2}$ feet. This mulplyed into 667, makes 62364: from whence tting away the three right hand figures, ere remaines 62. $\frac{364}{}$ or $62\frac{1}{3}$ feet, for the diance H K.

IV. *To finde part of a diſtance.*

the diſtance of K from Z were requid. Firſt, finde H K, then H Z, by the d precedent: their difference is K Z. If

K Z wee

K Z were a trench, you might from the tower F, finde the breadth of it without any approach unto it.

V. *To finde a height at two obſervations.*

IF F H were to be meaſured, and the way from E to H were unpaſſeable, ſo that the diſtance of E from H could not be meaſured. You muſt in this caſe make two obſervations. For which purpoſe, Take your firſt ſtation at E, and direct the ſights D, A, to the point F: noting what parts the threed cuts upon the equall limbe from C to B. Then goe backwards in a right line, to a competent diſtance as to M; and there making a ſecond ſtation, obſerve (as before) what degrees the threed cuts upon the equall limbe from N to O: (the two ſights L, I, being juſtly directed to the point F). Then count theſe two arkes in the equall limbe, from the contrary ſide of the quadrant, namely, from D to Y and from L to *u*, and applying the threed thereto, looke what parts it cuts from the meaſuring Scale at Y, and V. Take the leſſer number of parts, out of the greater, noting the Difference. Meaſure alſo the diſtance of

you

your two ſtations, namely from E to M, and add three cyphers to that meaſure. This laſt number muſt (in this kinde of worke) be divided alwayes, by the fore-noted difference: and the quotient will give the Altitude of F above G.

Example. Let the firſt obſervation cut off $38\frac{2}{3}$ *gr.* in the equall limbe. The ſecond $56\frac{1}{3}$ *gr.* Count the firſt arke from D to Y: the threed there laid gives 1250 in the meaſuring Scale. The ſecond ſo counted from L to V, gives 667. The difference of theſe two, is 583. Let the diſtance of the ſtations meaſured from E to M, be 5160 feet. This number, with three cyphers added, is 5160000. Which divided by 583 (the former difference) gives in the quotient, 8850 or $88\frac{1}{3}$ feet for the height G F. And if G H be 5 foot more; The whole height H F will be $93\frac{1}{3}$ feet.

☞ Note that in theſe menſurations, the point G is ſuppoſed to ſtand in the ſame levell with the corner of your Quadrant D and L. So that G H, D E, L M, are all of one height. And note too, that the two ſtationary points are E and M, namely thoſe which are juſt under the corners D and L.

FINIS.

Errata.

Pag.	*Line.*	*Read.*
6	1	Ninetyeth.
11	21	the threed laid at K.
14	25	horizon, is 29 *gr.* 21 *min.*
16	19.20	cuts from F & Count
25	13	Count the plaines
26	19	the Suns altitude.
34	2	the line C D E
52	16	quadrant, close by
53	15	the same name or number
53	25	$\frac{1}{3}$ part of a quarter.
56	1	Altimetric
56	4	Altimetric.

As the difference of the
Cotangents of the Arkes cut
at either Station
Is to the distance between
those Stations
So y^e Radius to the right
of the Tower about the Eye
And so y^e Cotangent of
the greater } Arke to the
lesser }
lesser } distance from y^e
greater } Station to the foot of the Tower
and so is the Cosecant of the
greater } Arke to the lesser }
lesser } greater }
distance from the top of the
Tower to ye Eye

And this may be applyed for
taking the Ordain of a right

To get the distance by the
Offset of Langonby Hartford &
or by standing at 45 first
and going just forward or
backward

Instead of taking a 3rd
Station to get the distance
from ye intended Station to
ye Tower

Or the Right coming had
Assistance of the Ark at
first Station to the second
So holding Racons to just
between the eye & the top
of the lower end by the Hand
Proportion a single Ark at
2^d^ Station & distance from
the end to the top of the Tower
may likewise be found

Propositions wrought on the Globe

EB

Ascensionall difference p 8 without the
Substile distance or declination p 10
without Compasses upright position
Difference of climate Longitude p 10
Without Compasses
Arke of ye horizon betwixt the
Equinoctiall and Horizon p 13 or of the
Arke of an Azimuth betweene Equinox
and Horizon

On EBN with Compasses
how high ☉ on any Azimuth and Declin
p 15 Azimuth p 21
Houre p 24 Angle betweene 12
and 6 9 In East or West
Be Lines Angle of 12 and 6
The Stile Elevation and the Plaine
difference of Longitude 45, 46

Amplitudo p 9 without Compasses

Sides Elevation p 10 without Compass

Differend of a plands Longitud p 11
without Compasses in Upright Dotinds

Howrs Circles angls with y^d Horizon or
Axmuth with y^d Equinoctiall 12 with
out Compasses

The ☉ Light at any howrs and Dotinatus
p 19
In East or West ortinds Declexion
p 44

Propositions wrought on both Lines

To make a Horizontall Dial p 11
with or without the Compasses

How high ☉ on any Axmuth and Declina
p 17 Angle Coprodons 12 and 6.
9 p 25 in Upright Dotinds

Altitude 28

To dispose any Proportion
into Two

Radius to greater middle Learne
So Sine of the other middle
Learne to a Fourth

Again as the first Learne to
that Fourth So Radius to
the Learne sought.

As 2 to 10 So 10 to 60

Latitude 52° 45′
37, 15

At ye Mill Bridge in
Westminster Lead by the
Mill Banks m^r Jackson

AVA